SnowEx-ABoVE Planning Meeting
July 9, 3pm Eastern Time (US & Canada)

Agenda:

- Updates from NASA HQ -- J. Entin -- 5 min
- Updates from ABoVE - - P. Griffith -- 5 min
- Updates/SnowEx-ABoVE plans in support of the SBG – CK Gatebe – 5 min
- Featured talks:
- Fred Huemmrich - Optical Remote Sensing of Springtime Photosynthetic Onset in Evergreen Conifers -- 15 min
- Cathy Wilson - NGEE-Arctic research activities on snow redistribution processes and impacts -- 15 min
- Discussions -- 15 min.

Surface Biology & Geology:
Snow Subgroup Updates

Highlight:

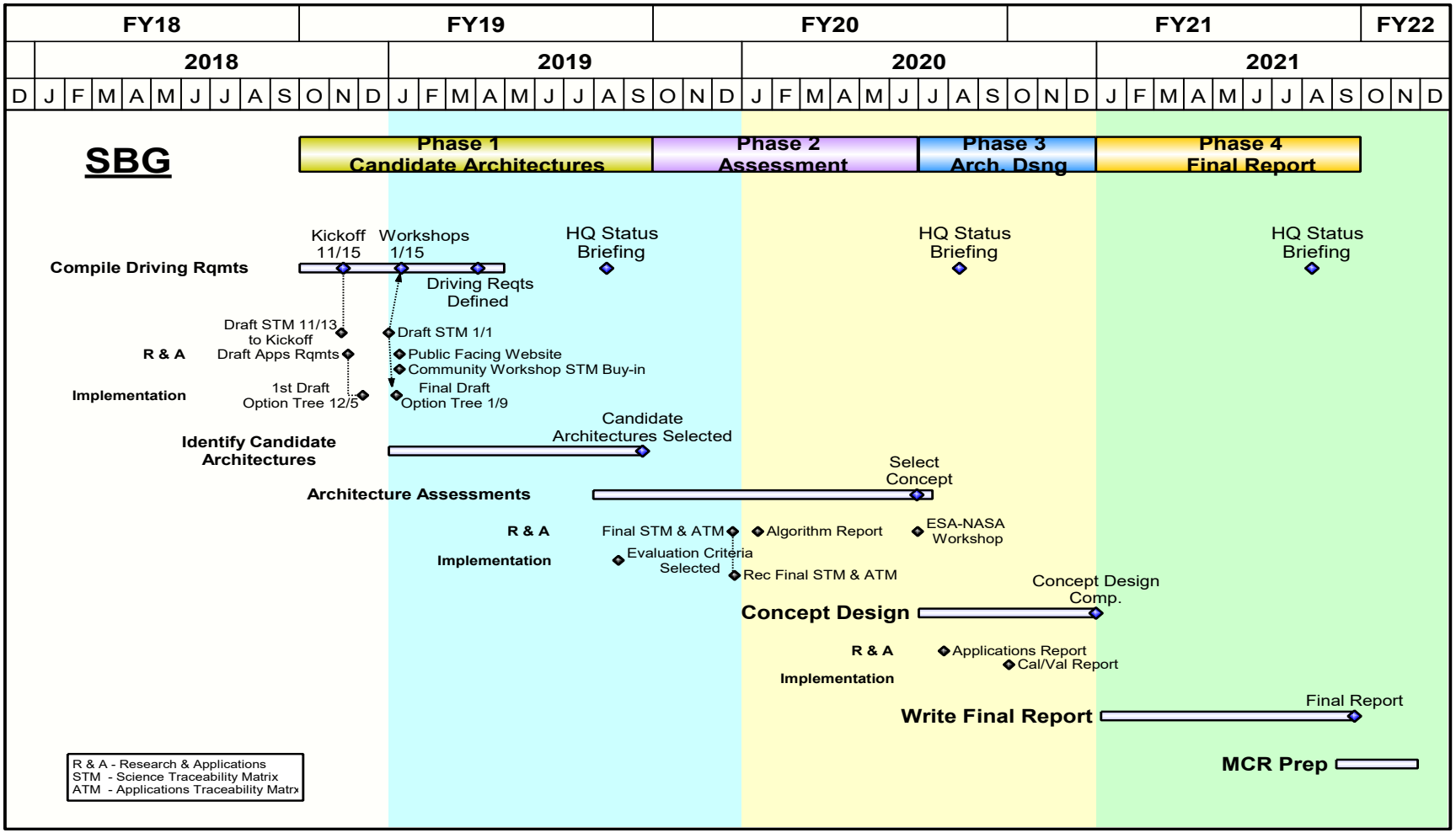
- **Snowscapes exert important global influences that affect weather and climate, natural resource accessibility, and human socio-economic systems.**

C. K. Gatebe, T. Painter, et al.,

SBG

- Surface Biology and Geology (SBG) one of the five designated observables (DOs) in the Decadal Survey.
- SBG will include both VSWIR hyperspectral and thermal measurements.
- Leverage the heritage of HyspIRI.

SBG Designated Observable Study Schedule



SBG SATM, v6 (2019 05 30)

STM for DS Targeted Observables TO-18 (Surface Biology & Geology)					
Decadal Survey Science Topics, Questions, Objectives, and Geophysical Observables					
Topic	DS Science Question	DS Science/Application Objective	Priority	DS Suggested Geophysical Parameters	Example SBG Geophysical Parameters
Global Hydrological Cycles and Water Resources	**H-1**. How is the water cycle changing? Are changes in evapotranspiration and precipitation accelerating, with greater rates of evapotranspiration and thereby precipitation, and how are these changes expressed in the space-time distribution of rainfall, snowfall, evapotranspiration, and the frequency and magnitude of extremes such as droughts and floods?	**H-1c.** Quantify rates of snow accumulation, snowmelt, ice melt, and sublimation from snow and ice worldwide at scales driven by topographic variability.	Most Important	Snow and glacier albedo and surface temperature. Spectral albedo of suxbpixel snow and glaciers at weekly intervals to an accuracy to estimate absorption of solar radiation to 10%.Ice/snow temperature to ± 1K. At spatial resolution of 30 to 100 m.	Snow and ice coverage fraction (cryosphere) Snow spectral albedo From Visible to Thermal (cryosphere) Snow surface temperature (cryosphere)
	H-2. How do anthropogenic changes in climate, land use, water use, and water storage, interact and modify the water and energy cycles locally, regionally and globally and what are the short- and long-term consequences?	**H-2a.** Quantify how changes in land use, water use, and water storage affect evapotranspiration rates, and how these in turn affect local and regional precipitation systems, groundwater recharge, temperature extremes, and carbon cycling.	Very Important	Latent heat flux. 3 (desirable) to 6 hour (useful) resolution during daytime intervals and at 1 km spatial scale with better than 10 W/m2 accuracy. Requires temperature of soil and vegetation separately at 40-100m spatial resolution, accuracy of +/- 1K, at temporal frequency to resolve the diurnal cycle. Albedo of soil and vegetation separately to an accuracy to estimate absorption of solar radiation to 10 W/m2, at weekly intervals at field scale, 30-60m spatial resolution.	VSWIR Spectral surface reflectance TIR emissivity Evapotranspiration rates of vegetation canopies with 10% uncertainty (multiple times of day) Surface temperature (multiple times of day)
	H-4. Hazards, Extremes, and Sea-level Rise. How does the water cycle interact with other Earth system processes to change the predictability and impacts of hazardous events and hazard chains (e.g., floods, wildfires, landslides, coastal loss, subsidence, droughts, human health, and ecosystem health), and how do we improve preparedness and mitigation of water-related extreme events?	**H-4a.** Monitor and understand hazard response in rugged terrain and land margins to heavy rainfall, temperature and evaporation extremes, and strong winds at multiple temporal and spatial scales.	Very Important	Magnitude and frequency of severe storms. Depth and extent of floods. Precipitation, snowmelt, water depth, and water flow in soil at time and space scales consistent with events.	See H1-c
	W-3. How do spatial variations in surface characteristics (influencing ocean and atmospheric dynamics, thermal inertia, and water) modify transfer between domains (air, ocean, land, cryosphere) and thereby influence weather and air quality?	**W-3a.** Determine how spatial variability in surface characteristics modifies regional cycles of energy, water, and momentum (stress) to an accuracy of 10 W/m2 in the enthalpy flux, and 0.1 N/m2 in stress, and observe total precipitation to an average accuracy of 15% over oceans and/or 25% over land and ice surfaces averaged over a 100 × 100 km region and 2- to 3-day time period.	Very Important	**Land SurfaceTemperature.** 0.6 K random uncertainty in 25 × 25 km area, 80% daily coverage, 3-5 km resolution, with 1 km resolution desired.	Land surface temperature (global 3-5 day repeat) Land surface temperature (derived, global daily repeat)

Working Groups (R&A):

- Algorithms
  - Phil Townsend, Kerry Cawse-Nicholson
    - Snow →Painter & Gatebe
- Applications
  - Jeff Luvall, Christine Lee
- Cal/Val
  - Kevin Turpie, Ray Kokaly
- Modeling
  - Ben Poulter, TBD
    - Snow →Gatebe

Algorithm Working Group

- 104 working group members
- Biweekly telecons (40-60 participants)
- 50+ contributors to Team Drive
- Subgroups in Geology, Aquatics, & Snow
- 92+ suggested products

SBG snow products:

Surface Biology & Geology)

SBG Example Geophysical Variables and Capabilities

Example SBG Geophysical Parameters	VSWIR Spatial	VSWIR Temporal	VSWIR Range	VSWIR Sensitivity	TIR Spatial	TIR Temporal	TIR Range	TIR Sensitivity	Notes	Enabled Applications	DO Synergies	Products called out by AWG	Level
Snow and ice coverage fraction (cryosphere)	A	A	A	B					R1, R8, R12	A1, A2, A4, A5, A6		Snow fraction	3
Snow spectral albedo From Visible to Thermal (cryosphere)	A	A	A	B	A	B	B	A	R1, R8, R12	A1, A2, A4		Snow albedo	3
Snow surface temperature (cryosphere)					A	B	B	A	R4, R5, R8	A3		Snow surface temperature	3
												Snow - light absorbing particles	3
												Snow algae concentration	3
												Snow grain size	3

H-1c. Quantify rates of snow accumulation, snowmelt, ice melt, and sublimation from snow and ice worldwide at scales driven by topographic variability. [Most Important]

Tasks:

- Consider available algorithms, their uncertainty and computing requirements,
- Consider whether any given algorithm should be applied globally or to a subset.
- Prepare prototype workflow for sample products
- Use and acquire precursor airborne and space-based imagery to demonstrate prototype level 3 and level 4 products
- Prepare a final report recommending algorithms for each product along with a list of required ATBDs.

Timeline

- April: List of algorithms and TRL
- June: End-to-end workflow for 2+ candidate algorithms
- All hands meeting in Washington DC, June 12-14
- September: Final report

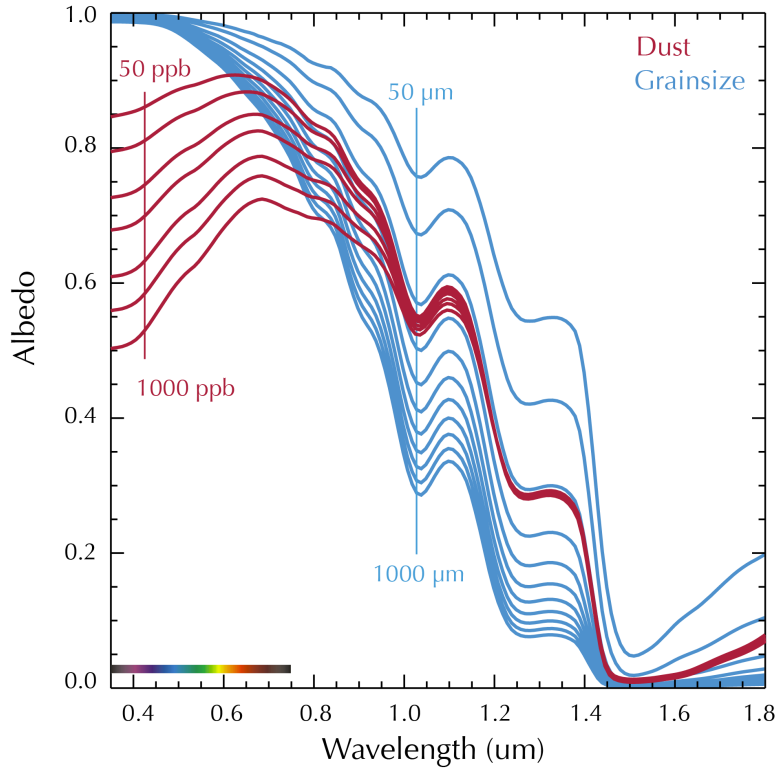
Snow cover mapping in forested and alpine-forested environments is challenging:

- ✓ Mixed pixel information
- ✓ Variable illumination
- ✓ Sensor viewing angle
- ✓ Shadow distribution
- ✓ 3D nature of the mixing process
- ✓ Structure and composition of forest canopies
- ✓ Primary spatial scale of action
- ✓ Sensor radiometric dynamic range

Changes in grain size and RF on α

$$\frac{d\alpha}{dt} = \frac{\partial \alpha}{\partial GS}\frac{\partial GS}{\partial t} + \frac{\partial \alpha}{\partial RF}\frac{\partial RF}{\partial t}$$

for a fixed solar zenith angle and spectral irradiance

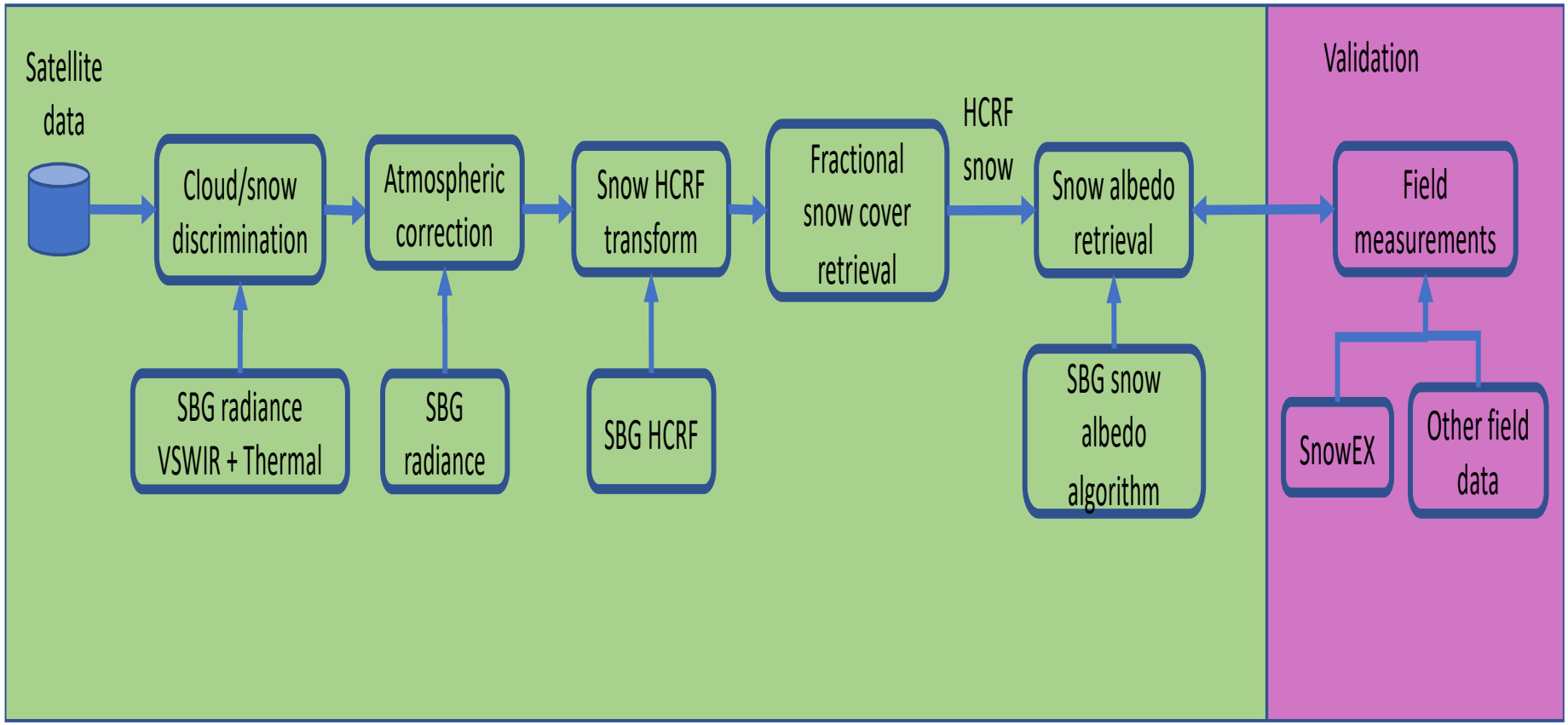


From Painter et al.

Current Activity:

The SBG Algorithms Working Group for snow is developing a synthetic dataset that mimics the radiative transfer process in a coupled atmosphere-snow system that can be used for testing of atmospheric correction (AC) and snow property retrieval algorithms. This framework provides a comprehensive and fair way to assess the performance of existing algorithms pre-launch for a wide range of environmental conditions.

A framework for assessing SBG snow retrieval algorithms:



From Chen, Fan, Li, Painter, Stamnes & Gatebe

Backup slides

SBG Precursor dataset: SnowEx-ABoVE in 2020-22/AK

Precursor dataset for SBG will be collected during the late winter/spring transition with two key sensors: AVIRIS hyperspectral data and directional reflectance measurements with CAR. L-band InSAR measurements will measure changes in dry snowpack conditions (SWE). Others sensors of interests are lidar (e.g., ASO, LVIS) and radar (e.g., SWESARR).

Disclaimer:
this mission is awaiting NASA HQ approval.

Slides from SBG/AWG courtesy Phil Townsend & Kerry Cawse-Nicholson

Products

Level 0

Level	Product	VSWIR	TIR
0	Cloud filter	X	X
0	Raw Digital Numbers (compression)	X	X
0	Dark Frame	X	X
0	Pointing	X	X
0	Prioritization	X	X

Products

Level 1

Level	Product	VSWIR	TIR
1	VSWIR calibrated at-sensor radiance	X	
1	TIR calibrated at-sensor radiance		X
1	Geolocation (base)	X	X
1A	Geolocation (landmark-aligned)	X	X
1T	Geolocation (terrain corrected)	X	X
1	Solar zenith and azimuth angles	X	X
1	Sensor zenith and azimuth angles	X	X

Products

Level 2

Level	Product	VSWIR	TIR
2	Surface reflectance	X	
2b	Water-leaving spectral reflectance*	X	
2b	BRDF/topo-corrected reflectance	X	
2	Land Surface Temperature/Emissivity		X
2	Water Surface Temperature		X
2b	Cloud shadow detection	X	X
2b	Haze detection	X	

Products – diagnostic for atmospheric correction

Level	Product	VSWIR	TIR
2b	Rayleigh corrected reflectance	X	
2b	Aerosol optical depth	X	
2b	Aerosol angstrom exponent	X	
2b	Glint correction	X	
2b	Polarization correction	X	
2b	Wind speed and direction	X	
2b	Temperature and humidity	X	
2b	Sun angle	X	
2b	Sea foam/bubbles	X	
2b	Atm trace gases (NO2 and O3)	X	
2b	Atm water content (…+ alg specific parameters)	X	

Products – vegetation

Level	Product	VSWIR	TIR
Int	Image normalization (traits) [cont rem, vecnorm]	X	
3	Vegetation water content (%water, EWT)	X	
3	Cover fractions (green, NPV, substrate, snow, water)	X	
3	Traits (chl, carotenoids, %N, LMA, *many others*)	X	
3	Plant functional types	X	
3	Taxonomic composition	X	
3	Wetland delineation and type	X	
3	Alpha/beta/gamma diversity	X	
3	Evapotranspiration	X	X
3	Crop composition	X	

Products – vegetation cont.

Level	Product	VSWIR	TIR
3	fAPARchl, fAPARnon-chl, fAPARcanopy	X	
3	LAI	X	
3	Vegetation LUE	X	
3	Plant photosynthetic capacity	X	(X)
3	Extended functional traits	X	
3	Basic vegetation indices (NDVI, EVI, PRI)	X	
3	Land surface phenology	X	
4	Evaporative stress index	X	X
4	Water use efficiency	X	X
4	Disturbance classification	X	
4	Soil carbon	X	

Products – snow

Level	Product	VSWIR	TIR
3	Snow albedo	X	
3	Snow – light absorbing particles	X	
3	Snow grain size	X	
3	Snow algae concentration	X	
3	Snow water equivalent	X	

Products – volcanos and fire

Level	Product	VSWIR	TIR
3	Lava temperature	X	X
4	Volcanic gas and particulate emissions	X	X
4	Volcanic lake color composition	X	
4	Volcanic thermal events		X
3	Fire temperature		X
3	Fire radiative power		X
4	Dead/dormant vegetation	X	
4	Live fuel moisture	X	
3	Burn severity	X	
3	Ammonia		X

Products – geology

Level	Product	VSWIR	TIR
Int	Continuum removal	X	
2	Feature wavelengths and depths	X	
3	Lithology mapping	X	X
3	Mineral mapping	X	X
3	Mineral spectral indices	X	X
4	Surface dynamics (geological hazards)	X	X
4	Geological type	X	X
4	Soil properties	X	

Products – aquatic

Level	Product	VSWIR	TIR
3	Water surface bulk temperature		X
3	Thermal anomaly detection		X
3	Inherent optical properties	X	
3	Benthic visible spectral reflectance	X	
3	Benthic cover classification	X	
3	Chlorophyll-a water column concentration	X	
3	1st order water quality parameters	X	
3	Harmful algal bloom indicators	X	
3	Noctiluca	X	
3	Trichodesmium	X	

Products – aquatic cont.

Level	Product	VSWIR	TIR
3	Karenia	X	
3	Red band difference	X	
3	High biomass event detection	X	
3	Pseudo-nitzschia	X	
3	Floating algal index	X	
3	Phytoplankton functional type	X	
3	Dissolved organic carbon	X	
3	Particulate organic carbon	X	
3	Particulate inorganic carbon	X	

Products – aquatic cont.

Level	Product	VSWIR	TIR
3	CDOM absorption at 440nm (or other wavelengths)	X	
3	CDOM spectral slope	X	
3	Normalized Fluorescence line height	X	
3	Adaptive reflectance peak height	X	
3	Turbidity	X	

Products – aquatic (from Applications WG)

Level	Product	VSWIR	TIR
4	Emergent and submerged macrophages/species	X	
4	Bathymetry	X	
4	Light attenuation	X	
3	Total suspended matter	X	
3	Phycocyanin	X	
3	Phycoerythrin	X	
3	Oil spills	X	

Products – other

Level	Product	VSWIR	TIR
3	GHG gases	X	
3	Thermal inertia and thermal conductivity		X